

# CS2030S PE2

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github.com/mendax1234

## Functional Interface

- (BooleanCondition<T>):
  - Lambda example:** BooleanCondition<Integer> isPositive = x -> x > 0;
  - Java equivalent:** Predicate<T>.
- (Producer<T>):
  - Lambda example:** Producer<Double> randomValue = () -> Math.random();
  - Java equivalent:** Supplier<T>.
- (Consumer<T>):
  - Lambda example:** Consumer<String> printUpperCase = s -> System.out.println(s.toUpperCase());
  - Java equivalent:** Consumer<T>
- (Transformer<U, T>): Tranform a value of type U into a value of type T.
  - Lambda example:** Transfomer<String, Integer> stringLength = s -> s.length();
  - Java equivalent:** Function<U,T>
- (Combiner<S, T, R>): Combine two values of type S, T into a value of type S.
  - Lambda example:** Combiner<Integer, Integer, Integer> multiply = (a, b) -> a \* b;
  - Java equivalent:** BiFunction<S, T, R>.
- Functional Interface Example**  
**@FunctionalInterface**  

```
public interface Valuable {  
    double getPrice();  
}
```

## List

- Create an empty List:**
  - Create an empty immutable list:** List<T> l = List.of();
  - Create an empty mutable list:** List<T> l = new ArrayList<>();
- Copy from a List to another:** This is usually used in the **constructor**, use this.fruits = new ArrayList<>(fruits);, where this.fruits is of type List<T> and fruits is of type List<? extends T> to avoid the type problems. And import java.util.ArrayList;
- List to stream:** use list.stream()
- Stream to list:** use stream.toList()
- isEmpty:** This function can be used to filter out the empty list from the stream.  

```
public boolean isEmpty() {  
    return this.books.isEmpty();  
}
```

  
filter() here will keep the elements that are **not empty!**

```
return bss.stream()  
            .map(bs -> Q7.applyDiscount(bs, k))  
            .filter(bs -> !bs.isEmpty())  
            .toList();
```

## Maybe

- Maybe.some always represents a **valid** value inside the wrapper. Maybe.None always represents **not found or value DNE**.
  - map:** if the target is Maybe.some, map will always add a Maybe.some wrapper! (Not calling Maybe.of!) **Can think of map() as a method that will return a value**
  - Use Maybe to rewrite if-else branch:**
    - Write conditions:** This is usually done by constructing a Maybe and using filter
    - Invoke the method in if-branch:** this can be done by using flatMap/map
      - To pass several parameters:** Chain flatMap() and map(), the result after this step is still a Maybe.
      - Change a different variable to use:** This can be done using flatMap()/map() also!
      - ifPresent:** this usually after the previous step, if need further operation on the result, use invoke the method using ifPresent. (**Think it as a function that returns void**)
    - Invoke the method in else-branch:** this can be done using orElse()/orElseGet()
      - These two methods are usually used to get the value from previous **Maybe** or produce a new value.
- ```
public void transfer(int from, int to, double amount) {  
    Maybe<Account> fromAccount = findAccount(from).filter(  
        ac -> !ac.isClosed() && ac.getBalance() > 0);  
    Maybe<Account> toAccount = findAccount(to).filter(ac -> !ac.isClosed());  
    toAccount.flatMap(tac -> fromAccount.map(f -> f.transferTo(tac, amount).getFirst()))  
        .ifPresent(fac2 -> accounts.put(from, fac2));  
    // if (fromAccount != null && toAccount != null && fromAccount.getBalance() > 0 &&  
    //     !fromAccount.isClosed() && !toAccount.isClosed()) {  
    //     fromAccount.transferTo(toAccount, amount);  
    // }  
}
```

- orElse()/orElseGet() Example:**  

```
String foo(Maybe<Object> m) {  
    return m.map(obj -> String.valueOf(obj)).orElse(t:"?");  
    // if (m.equals(Maybe.none()) {  
    //     return "?";  
    // }  
    // return String.valueOf(m.get());  
}
```
- Main Method Descriptor**
  - filter(BooleanCondition<? super T> c): Only keep the value in the Maybe wrapper if it **pass the test**
  - map(Transformer<? super T, ? extends U> t)
  - flatMap(Transformer<? super T, ? extends Maybe<? extends U>> t)
  - orElse(T t)
  - orElseGet(Producer<? extends T> p)
  - ifPresent(Consumer<? super T> c)
  - of(T t): if t == null, return Maybe.none(). Else, return Maybe.some(t).

## Lazy

- Basic:** Lazy can store either an **already existed value** (Wrapped by Maybe.some) or a **producer which will be used to produce a value**.

- The memoization thinking** in Lazy::get(), also an example for multiple lines lambda  

```
public T get() {  
    return this.value.orElseGet(  
        () -> {  
            T compute = this.producer.produce();  
            this.value = Maybe.some(compute);  
            return compute;  
        });  
}
```
- Lazy List Example:**  

```
public static <T> LazyList<T> generate(  
    int n, T seed, Transformer<T, T> f) {  
    List<LazyT>> lazyList = new ArrayList<>();  
    Lazy<T> curr = Lazy.of(seed);  
    for (int i = 0; i < n; i++) {  
        lazyList.add(curr);  
        curr = curr.map(f);  
    }  
    return new LazyList<>(lazyList);  
}
```

## Infinite List

- Traverse through the infinite list:**  

```
public void forEach(Consumer<? super T> action) {  
    InfiniteList<T> currList = this;  
    while (!currList.isSentinel()) {  
        // Consume the head  
        currList.head.get().ifPresent(action);  
        // Shrink the sublist  
        currList = currList.tail.get();  
    }  
}
```

## Stream

- When using the **intermediate operation** on stream, use the good practice to write lambda as each element -> what operation. e.g. fruits.stream().map(fruit -> String.format("%- %s", fruit));
- reduce():** It's workflow is like that **result = identity** → **for each element in the stream; result = accumulator.apply(result, element); return result**
  - reduce(identity, accumulator): the identity and element in the stream must be of the **same type!**  

```
return sortedAccounts.stream()  
    .filter(ac -> !ac.isClosed())  
    .map(ac -> ac.toString())  
    .reduce("", (a, b) -> String.format("%s\n", a + b));  
    // for (Account account : sortedAccounts) {  
    //     if (!account.isClosed()) {  
    //         s += account + "\n";  
    //     }  
    // }  
    // return s;
```
  - reduce(identity, accumulator, combiner): the **identity may not be the same type** as the **element in the stream**
    - Combiner** is (a,b) -> a + b, this is usually used for the summation of the stream elements.
    - Combiner** is (a,b) -> a \* b, this is usually used for the product of the stream elements.

- The other Combiner like (a,b) -> a - b and (a,b) -> a / b are **not safe!** Don't use!  

```
/**  
 * Return the details of all accounts in the bank as a string.  
 */  
public String allAccounts() {  
    return getAccountStream()  
        .filter(a -> !a.isClosed())  
        .sorted((x, y) -> Double.compare(y.getBalance(), x.getBalance()))  
        .reduce("", (s, a) -> s + a + "\n", (s, a) -> s + a);  
}
```

- Explicitly cast the return type:** This can be done by changing the type of **identity** in reduce  

```
public class Q6 {  
    public static <T extends Book> List<BookShop<Book>>  
        consolidateShopsByGenre(List<? extends BookShop<? extends T>> bss) {  
        return Q5.findUniqueGenres(bss)  
            .stream()  
            .map(genre ->  
                bss.stream()  
                    .map(bs -> new BookShop<Book>(bs.findBooksByGenre(genre)))  
                    .reduce(new BookShop<Book>(), (a, b) -> Q4.mergeShops(a, b)))  
            .toList();  
    }  
}
```

- map():** transforms **each element** in the stream by **applying a function (transformer)** to it, producing a new stream of the transformed elements with a **one-to-one relationship**.  
For example, here the **name** and the **cost after reducing** has a **one-to-one relationship**  

```
public static Stream<String> totaledCustomerCosts(  
    Map<String, List<Integer>>> customerTable,  
    Map<Integer, Double>> salesTable) {  
    return customerTable.keySet().stream()  
        .map(name ->  
            name + ": "  
                + Query.getCostsFromName(customerTable, salesTable, name)  
                    .reduce(identity:0.0, (a, b) -> a + b));  
}
```
- flatMap():** transforms **each element** into a **stream** and then **flattens** all resulting streams into a single stream, useful for working **with nested collections** or **when one element should produce multiple output elements**.  
For example, here the **name** and the **cost** has a **one-to-multiple relationship**  

```
public static Stream<String> allCustomerCosts(  
    Map<String, List<Integer>>> customerTable,  
    Map<Integer, Double>> salesTable) {  
    return customerTable.keySet().stream()  
        .flatMap(name ->  
            Query.getCostsFromName(customerTable, salesTable, name)  
                .map(x -> name + ": " + x));  
}
```
- filter():** Creates a new stream that keeps **only the elements that passed the test** in Predicate.
- none/any/allMatch():** a **boolean** method. It returns true only if **no/any/all** element in the stream **passes the predicate test**.
- sorted():** elements according to **natural order** (small to big or ascending order) or a **provided comparator**  
The following provides an example on sorted as well as how to use reduce to find maximum/minimum value in a stream

```
class Q8 {
    static class ShopComparator<T extends Book>
    implements Comparator<BookShop<? extends T>> {
        public int compare(
            BookShop<? extends T> stall1, BookShop<? extends T> stall2) {
            return (int) (stall1.getBooks().stream()
                .map(Book::getPrice)
                .reduce(Double.MAX_VALUE, Math::min)
                - stall2.getBooks().stream()
                .map(Book::getPrice)
                .reduce(Double.MAX_VALUE, Math::min));
        }
    }

    public static <T extends Book> List<BookShop<Book>> searchForBook(
        List<? extends BookShop<? extends T>> bss, String title) {
        return bss.stream()
            .filter(bs -> bs.hasBook(title))
            .map(bs -> new BookShop<Book>()
                .bs.getBooks().stream()
                .filter(book -> book.hasTitle(title))
                .toList())
            .sorted(new ShopComparator<>())
            .map(bs -> new BookShop<Book>(bs.getBooks()))
            .toList();
    }
}
```

Monad and Functors

- 1. **Monad Laws:**
  - **The left identity law:** `Monad.of(x).flatMap(x -> f(x))` must be the same as `f(x)`
  - **The right identity law:** `monad.flatMap(x -> Monad.of(x))` must be the same as `monad`

- **The associative law:** `monad.flatMap(x -> f(x)).flatMap(x -> g(x))` must be the same as `monad.flatMap(x -> f(x).flatMap(y -> g(y)))`
- 2. **Functor Laws:**
  - **Identity Law:** `functor.map(x -> x)` is the same as `functor`
  - **Composition Law:** `functor.map(x -> f(x)).map(x -> g(x))` is the same as `functor.map(x -> g(f(x)))`.

Miscs

- 1. **(Bounded type parameter):** A type parameter, like `T` can have a bound! e.g., `T extends Fruit` means the type parameter `T` must be a subtype of `Fruit`.
- 2. **Make your method as flexible as possible!:** Usually, we use **producer extends** more.
- 3. **(Immutable class):**
  - When you are designing a class with a `List` as its member and you may use stream later, think about making it final to make the class immutable.
  - For Java **arrays** and **String**, just add keyword **final**.
  - When return a **non-primitive** type, **make a hard copy!** For example, to make a hard copy of `List`, the first argument is your `List` object, the second element is the length of your `List`.

- ```
public Customer[] getOwners() {
    return Arrays.copyOf(this.owners, this.owners.length);
}
```
- 4. **General advice for writing one-liner**
    - Start by considering the condition to use (This should be a object of type `Maybe`)
    - End by using `orElse()`/`orElseGet()`.
      - Anything between the start and the end is your **if branch**.
      - The "placeholder" in your end (in the `orElse()`/`orElseGet()`) is the **else branch**.
  - 5. **Print Modifier:**

Specifier	Data Type
<code>%d</code>	Integer (decimal)
<code>%f</code>	Floating point (decimal)
<code>%s</code>	String
<code>%c</code>	Character
<code>%b</code>	Boolean
<code>%%</code>	Literal % sign

- To print the decimal point, we use `%.2f`(2 decimal places)
- 6. **Write a class with one static method:** In case need other methods, can also write like below

```
class Q7 {
    static class DiscountedBook extends Book {
        public DiscountedBook(Book b, double discount) {
            super(
                b.getTitle(), b.getGenre(),
                () -> b.getPrice() * (100 - discount) / 100
            );
        }
    }

    private static <T extends Book> BookShop<DiscountedBook>
    applyDiscount(BookShop<? extends T> bs, int k) {
        int bookNum = bs.getBooks()
            .stream()
            .reduce(
                identity:0, (a, b) -> a + 1,
                (a, b) -> a + b);

        if (bookNum < k) {
            return new BookShop<DiscountedBook>(
                bs.getBooks().stream()
                    .map(book ->
                        new DiscountedBook(book, discount:50))
                    .toList());
        }
        return new BookShop<DiscountedBook>();
    }

    public static <T extends Book> List<BookShop<DiscountedBook>>
    discountRemainingStock(
        List<? extends BookShop<? extends T>> bss, int k) {
        return bss.stream()
            .map(bs -> Q7.applyDiscount(bs, k))
            .filter(bs -> !bs.isEmpty())
            .toList();
    }
}
```